VALIDATION OF A MANUALLY OSCILLATING CHAIR FOR IN-THE-FIELD ASSESSMENT OF DYNAMIC VISUAL ACUITY ON CREWMEMBERS WITHIN HOURS OF RETURNING FROM LONG-DURATION SPACEFLIGHT

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Long-duration spaceflight results in sensorimotor adaptations, which cause functional deficits during gravitational transitions, such as landing on a planetary surface after long-duration microgravity exposure. Both the vestibular system and the central nervous system are affected by gravitational transitions. These systems are responsible for coordinating head and eye movements via the vestibulo-ocular reflex (VOR) and go through an adaptation period upon exposure to microgravity. Consequently, they must also re-adapt to Earth's gravitational environment upon landing. This re-adaptation causes decrements in gaze control and dynamic visual acuity, with crewmembers reporting oscillopsia and blurred vision caused by retinal slip, or the inability to keep an image focused on their retina. This is thought to drive motion sickness symptoms experienced by most crewmembers following landing. Retinal slip can be estimated by dynamic visual acuity (DVA); visual acuity while in motion.

Previously, DVA has been assessed in the laboratory where subjects walked at 6.4 km/hr on a motorized treadmill. Using this method, Peters et al. (2011) found that DVA is worsened in astronauts by an average of 0.75 eye-chart lines one day after landing. However, it is believed that re-adaptation occurs quickly and that DVA might be worse immediately upon re-exposure to a gravitational environment. Since many crewmembers are unable to walk safely upon landing, it was necessary to develop a method for replicating the vertical head movements associated with walking. In addition, the use of a chair to imitate the head displacement caused by walking isolates eye-head interactions without allowing for trunk and lower-body compensation, as seen with treadmill walking (Mulavara & Bloomberg 2003). Therefore, a modality for assessing DVA in the field within a few hours of landing was developed. In this study, we validated the ability of a manually operated oscillating chair to reproduce the oscillatory frequency of walking on a treadmill.

Healthy non-astronaut subjects (n=14) participated in one test session and completed three static (seated) and three dynamic (walking/oscillated) visual acuity tests. DVA was assessed using a motorized treadmill, an automated oscillating chair, and a manually operated chair, both developed in the Neuroscience Laboratory at JSC. The automated chair was motor-driven and set to oscillate vertically at 2 Hz with a vertical displacement of +/- 5 cm to simulate vertical translation while walking. The manually operated chair was oscillated vertically by a test operator to the beat of a metronome at 120 beats/min (2 Hz) and a vertical displacement of approximately +/- 5 cm. As the subject was oscillated, they were asked to discern the direction gap of Landolt-C optotypes of varying sizes and verbally reported the direction while an operator recorded their response using a gamepad. Subjects were outfitted with accelerometers (sampling rate = 128 Hz) on their head, trunk and lumbar spine. A fast Fourier transform was performed on the vertical trunk acceleration to compare the peak and spread of the distribution of oscillation frequencies for each oscillating condition.

The spread of the frequency distribution for the manual chair was not significantly different from either the treadmill or the automated chair. However, all three conditions had similar non-zero standard error values, suggesting a variance in head movement frequency which may affect DVA. The average oscillation frequency of the manual chair (1.85 Hz) was significantly different (α=0.05) from that of treadmill walking (2.24 Hz), but not significantly different from that of the automated chair (1.85 Hz) and all three conditions had small standard errors (SEM = 0.04, 0.06, and 0.08 Hz for manual, treadmill, and automated respectively). This implies that both chairs oscillate at a frequency below that of treadmill walking, but are comparable to each other and reproducible across sessions. Additionally, DVA scores did not vary significantly across conditions. The smaller spread values of the oscillating chairs' frequencies indicated mitigation of variation induced by locomotor strategies, which enables better examination of the issue of VOR adaptation. Furthermore, due to the deconditioned state of crewmembers in the initial hours after landing, it is easier to transport a manual bouncing chair into the field and safer to perform a vision test while seated in a chair versus walking on a treadmill. Therefore, the manually oscillating chair has been deemed to meet and exceed the DVA testing capabilities previously obtained by treadmill walking.

This work is partially supported by the National Space Biomedical Research Institute through NCC 9-58.